



Conference Paper

Structural and Textural State of a Corrosion-Resistant Super Alloys Ni–Cr–Mo System after Deformation

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Abstract

The structural and textural state of the nickel-based alloy (Ni–Cr–Mo) after cold rolling with degree of strain ~ 0.7 was investigated by means of electron backscatter diffraction (EBSD). It is shown that a multicomponent texture is formed during the deformation, including orientations: strong $\{110\} \langle 112 \rangle$, and weaker $\{110\} \langle 001 \rangle$ and $\{110\} \langle 111 \rangle$. The structure contains band elements of the mesostructure, which can be interpreted as deformation twins and shear bands. The orientation of the crystal lattice in all bands formed in grains with the main component of the texture $\sim \{110\} \langle 112 \rangle$ is close to $\{110\} \langle 001 \rangle$. This orientation is connected to the matrix, by turning at an angle of 70° around the transverse direction. It corresponds to the twin disorientation or the coincidence site lattice special (CLS) $\Sigma 3$ (60° , $ocb \langle 111 \rangle$). It is shown that all band elements of the mesostructure in the alloy are formed by the mechanism of deformation twinning. Moreover, the special disorientation formed at the beginning of the process (the special boundary $\Sigma 3$), is preserved in the deformation process as an energy stable object.

Keywords: FCC-metal, cold rolling, twinning, shear bands, texture.

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1. Results and Discussion

Research of structural and textural states in FCC-metals with a low and average value of the energy of a packaging defects are of great interest until the present time [1–5]. Special attention is paid to the formation of mesostructures such as twins and shear bands (SBs) during the deformation and recrystallization of such elements of the mesostructure.

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Crystallographic orientations, which are contained in these elements of the mesostructure, have a dominant influence on the formation of a texture state during recrystallization annealing, and, as a result, determine both technological and functional orientation-dependent properties of products from FCC-metals [1, 2].

The aim of the work was to establish the structural and textural state of the alloy with an FCC-lattice after cold rolling deformation, which is characterized by a low energy value of the packaging defect.

The material for the research was a corrosion-resistant superalloy of the Ni–Cr–Mo system, wares from this alloy are used in aggressive media at high temperatures. The starting material had a recrystallized (annealed) state before deformation. Under laboratory conditions, the process of flat cold rolling of a sheet was modeled (the diameter of the rolls is much larger than the cross-section of the product). The degree of deformation was ~ 0.7 . Texture analysis was performed by the method of electron backscatter diffraction (EBSD) on a two-beam electron-ion microscope (system) ZEISS CrossBeam AURIGA.

During the deformation, the structural state was obtained, shown in Fig. 1. Grains strongly elongated along the rolling direction (RD) had dimensions in cross section from 10 to 40 microns. Also structural analysis showed the presence of a large number of bands representing deformation twins (TWs) and / or shear bands (SBs). The amount and width of the bands differed in different grains. In some grains there were intersecting bands forming the "fishbone" mesostructure. The range of tilt angles of the all mesostructure elements to the RD was 10 to 35°. From these works [4,6–8], the tilt angles of the SBs to the direction of deformation can lie in the range from 10° to 45°.

A texture analysis of the sheet was carried out over the entire cross section of the samples after cold rolling to assess the deformation state. The integral texture is a set of orientations, including the strong components $\{110\} < 112 >$ and the weaker components $\{110\} < 001 >$, $\{110\} < 111 >$ (Fig. 2). All orientations are typical for rolling texture (RT) of FCC-metals. As a rule, shear texture is formed in the surface zone of the sheet during rolling, different from RT [9, 10]. In this case, only the components of the RT are present over the entire section of the sheet. Apparently, this is due to the conditions of the experiment: rolling was carried out without tension, with a large diameter of the rolls.

Also in this paper, questions of the relationship between the orientations of the matrix and crystallites within the bands constituting the mesostructure are considered. Due to the increased density of dislocations, the internal structure of most bands did not give

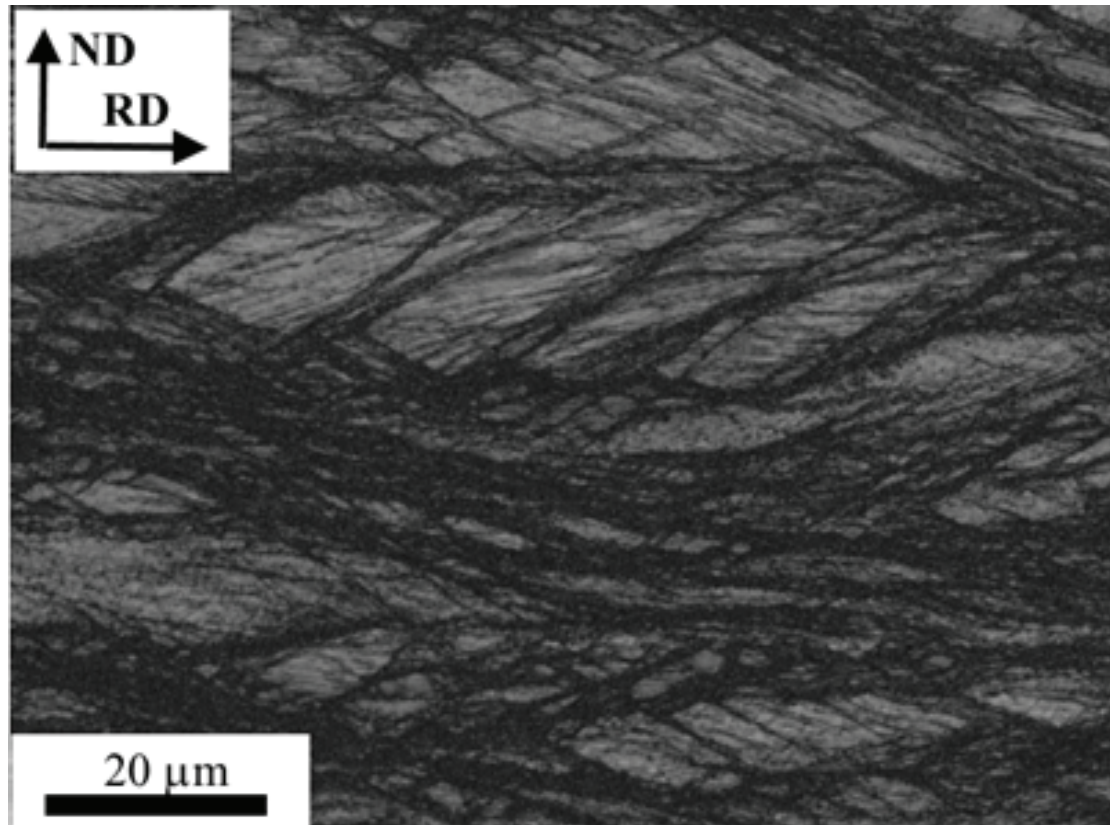


Figure 1: Structural state of the alloy after deformation.

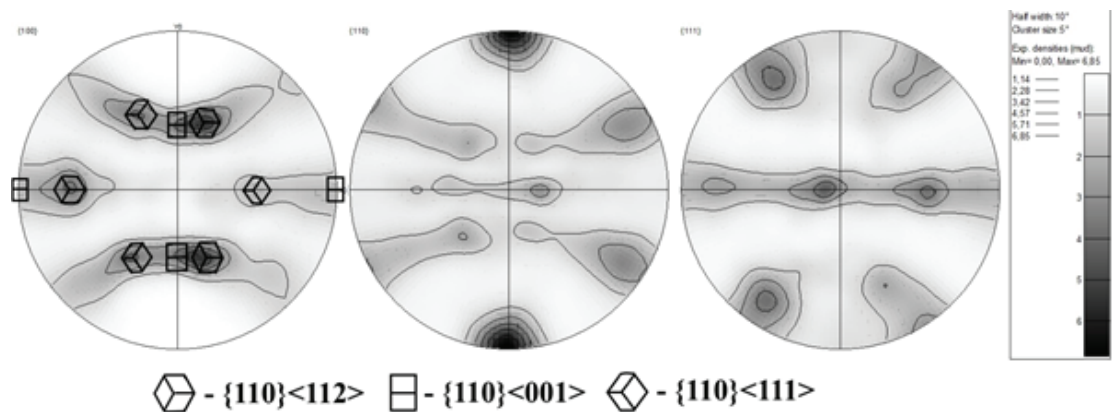


Figure 2: Pole figures of integral texture after deformation with decoding of texture components.

in to identification. In this connection, only the orientations of individual elements within the bands and the matrix in which they were formed were determined (Fig. 3).

Texture analysis showed that the crystal lattice inside the bands arising in the grains of the main matrix orientation $\{110\} \langle 112 \rangle$, regardless of their width and angle of inclination to RD, has an orientation close to $\{110\} \langle 001 \rangle$ (Fig. 3). All pole figures (Fig. 3,b–d), corresponding to the orientation map (Fig. 3,a), show that the orientations of the objects of the mesostructure are strongly scattered. The orientation of the matrix $\{110\} \langle 112 \rangle$

is also not absolutely stable, somewhat dissipates in the process of deformation. The formation of the $\{110\} \langle 001 \rangle$ texture component inside SBs has been discussed in a number of papers [4,6,11–13]. Moreover, the shear orientation inside SBs was associated with the orientation of the matrix by rotating around TD, as in the present work. In this case, the orientation of the matrix and the elements of the mesostructure are connected to each other by turning an angle of $\sim 70^\circ$ around the axis $\langle 110 \rangle$ parallel to TD (or turning the angle of $\sim 60^\circ$ around the axis $\langle 111 \rangle$ slightly deviated from ND). That is, the orientation of the band relative to the matrix is close to the special misorientation $\Sigma 3$ (60° , axis $\langle 111 \rangle$) from the from the coincidence site lattice (CSL), which is also a twin disorientation.

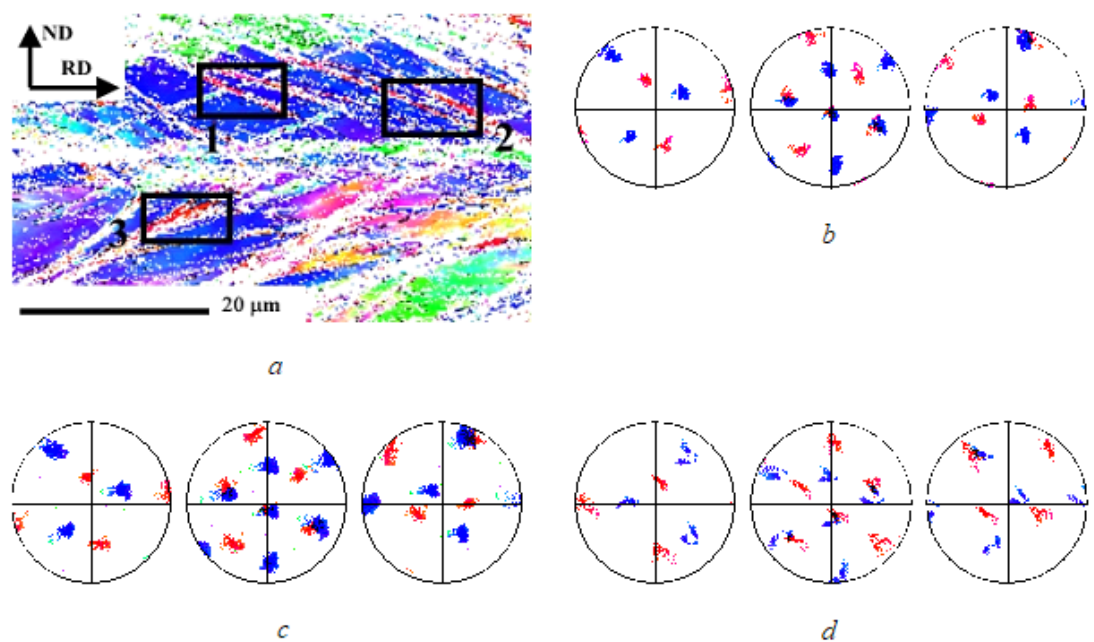


Figure 3: Microstructure and texture of the sheet area after cold rolling: *a* - orientation map with RD; *b*–*d* – pole figures $\{100\}$, $\{110\}$, $\{110\}$, corresponding to microregions 1–3, divided into “*a*” by rectangles, respectively

The histogram of the distribution of the CSL boundaries also indicates the presence of the dominant special disorientation of the CSL $\Sigma 3$ in the deformed state (Fig. 4).

In FCC-metals with an average and low energy of a packing defect, the deformation is carried out also by the mechanism of deformation twinning [14]. Thus, the presence of $\Sigma 3$ CSL in the deformed state in the FCC-metal can be explained by the preservation in the deformation process of the twin boundaries arising during twinning at the beginning of the deformation. That is, during deformation, the crystallites are reoriented with retaining the $\Sigma 3$ boundary, as an energetically favorable state of the arrangement of atoms in accordance with the results of [15–17].

It is worth noting that the CSL $\Sigma 25b$ is in the deformed state in the material.

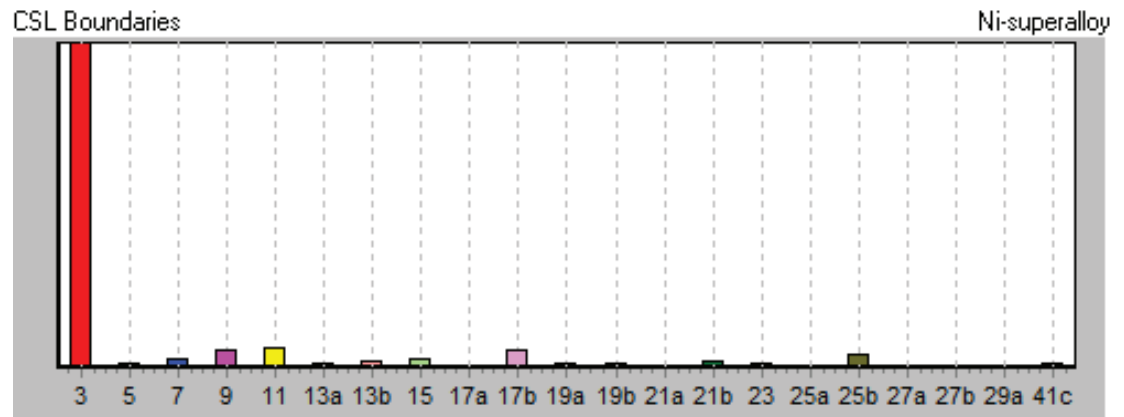


Figure 4: Distribution of the CSL boundaries in the deformed state, obtained by extrapolation of the initial points (data) to their intersection.

2. Conclusion

1. It has been established that a multicomponent rolling texture is formed during cold rolling of Ni–Cr–Mo nickel-based alloy, including: a strongly pronounced component $\{110\} \langle 112 \rangle$ and weaker components $\{110\} \langle 001 \rangle$, $\{110\} \langle 111 \rangle$.
2. The textural component $\{110\} \langle 001 \rangle$ is located in bands representing deformation twins and shear bands formed at different stages of deformation in the matrix grains $\{110\} \langle 112 \rangle$. The formation of orientation in the bands can be represented as a rotation around TD (close to the crystallographic direction $\langle 110 \rangle$) at an angle of $\sim 70^\circ$. Such a misorientation corresponds to the twinning misorientation of the CSL $\Sigma 3$ (60° , axis $\langle 111 \rangle$).
3. The special disorientation (special boundary $\Sigma 3$) formed at the beginning of the process of deformation is preserved in the deformation process as an energetically stable object.

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